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ABSTRACT

Learner and program control of content review within computer assisted instruction (CAI) were studied to determine their effects on the posttest performance and attitudes of eighth grade students. The science-related instructional treatments were completed by 98 students who were blocked by gender and reading ability and randomly assigned to experimental treatments. It was found that students under learner control scored significantly higher on the posttest than those under program control, and males had significantly higher posttest scores than females and more favorable attitudes toward the instruction and toward computer use. A significant treatment X gender X reading ability interaction indicated that the differences in favor of learner control were due primarily to the significantly higher performance by high ability females and low ability males under learner control than under program control. Time to completion was the same for both groups of subjects. Overall results indicate that students under limited learner control adjust their study behavior to achieve greater learning in the same amount of time. Twenty-six references are listed, and statistical analyses are appended. (Author/MES)

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# Learner Versus Program Control in Computer Assisted Instruction

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Abstract

Learner and program control of content review within computer-assisted instruction (CAI) were studied to determine the effects on posttest performance and attitudes. The science related instructional treatments were completed by 98 eighth grade students who were blocked by gender and reading ability and randomly assigned to experimental treatments. Students under learner control scored significantly higher on the posttest than those under program control, $F(1,90) = 4.653$, $p < .03$. Males had significantly higher posttest scores than females, ($F(1,90) = 7.233$, $p < .01$), and significantly more favorable attitudes toward the instruction and toward computer use. A significant treatment X gender X reading ability interaction indicated that the differences in favor of learner control were due primarily to the significantly higher performance by high ability females and low ability males under learner control than under program control. Time to completion was the same for both program control and learner control subjects. The overall results indicate that students under limited learner control adjust their study behaviors to achieve greater learning in the same amount of time.

# Learner Versus Program Control in Computer Assisted Instruction

## Introduction

Research in the areas of Aptitude-Treatment Interaction (ATI) and learner control of instruction has risen from a recognition that no one instructional treatment can be best for all learners. The goal of ATI research has been to adapt instruction to individual learners by tapping aptitudes the learners have or compensating for abilities they lack. Results over the last twenty years have been inconclusive, with general ability as the best predictor of performance (Cronbach & Snow, 1977).

Some argue that adaptive instruction is less than effective over the long term. For example, Yalow (1980) found that adaptive instructional supplements yielded positive results for less able learners on an immediate measure. However, these supplements yielded lower long-term retention for learners, perhaps because they reduced the processing the students performed on the information.

Rather than adapt instruction to the learner, Merrill (1975, 1980) has suggested that the learner be allowed to adapt to the instruction. Learner control over aspects of instruction has been viewed as a means of doing this. Control within instruction can range from complete external control (by the instructor or the computer), to total internal, or learner control. Under instructional systems that emphasize learner control, individuals may learn to control and process information in a variety of situations, rather than becoming dependent upon adaptive instructional systems. When learners make conscious choices concerning their instructional path, they may process more of the information themselves and process it more deeply. Deeper processing has been shown to increase retention.

Results of research examining the effects of learner control on performance have been mixed. Some research has indicated that individuals can successfully control their own learning (Mager, 1964; Campanizzi, 1978). Tennyson (1980, 1981; Tennyson & Buttrey, 1980) has found that, given advisement, learners can control their own instruction quite effectively. Other research has shown learner control to result in ineffective instructional choices (Steinberg, 1977; Fry, 1972; and Fisher, Blackwell, Garcia, & Greene, 1975).

Snow (1980) has suggested that some students simply may not be able to make effective use of learner control. Snow argues that "learner control cannot be expected to overcome the persistent fact that individual characteristics *not* under the control of the individual will determine to a significant extent what and how much that individual will learn in a given instructional setting" (p.152-3). One such individual characteristic that has been found to impact the efficacy of learner control is ability. Fry (1972) found effective use of learner control to be linked to high ability, as measured by tests of school aptitude.

Different results are obtained when student attitudes are considered. Fry (1972) and Hurlock and his associates (cited in Tennyson & Rothen, 1979) report more positive student attitudes from learner control than from program control. Fisher and colleagues (Fisher, et al., 1975) noted greater student engagement when a learner control treatment was used. However, as Clark (1980) points out, what a student prefers is not necessarily what is best for the student. For example, Peterson and Janicki (1979) found that students who preferred small group instruction learned less when placed in small groups than in large ones.

Atkinson (1972) has recommended that there "is a place for the learner's judgments in making instructional decisions...however, using the learner's judgment as one of several items of information in making an instructional decision is quite different from proposing

that the learner should have complete control" (p. 930). A current thrust of research on learner control is a determination of which elements of instruction the learner should have control over.

This study compared the effectiveness of learner control and program control on student learning and attitudes. The impact of gender and reading ability was also examined. Gender differences have been found in performance and attitudes in the study of mathematics and science, and in the use of computers (Maccoby & Jacklin, 1974; Miura, 1986; Lepper & Chabay, 1985). Verbal ability has frequently been shown to interact with treatments that are highly verbal (Cronbach & Snow, 1977).

The amount of learner control made available to subjects in this study was intentionally limited. The instruction that served as a base for this research was designed so that sound instructional procedures were incorporated whether learners chose high or low amounts of additional instruction.

## Method

### Subjects

Subjects were 98 eighth grade students, 46 females and 53 males, from science classes in a suburban junior high school. For all subjects, the median standardized reading test score from the previous year (7th grade), expressed as a grade equivalent, was 8.2.

### Materials

The unit which served as the base for this study covered an introduction to solar energy. The content was developed from Energy Choices and Challenges, part of The Energy Source Program, a nationally distributed energy education series (Energy Choices and Challenges, 1984). The material was first scaled down to a seventh grade reading level, and practice and test questions were generated. The resulting unit then underwent

expert review for currency and accuracy of information. Two classroom tryouts of the unit were conducted in pencil/paper format and one in computer-based format, each with accompanying revisions. The unit was designed as a series of informational screens containing text and graphics. Fifteen multiple choice practice questions, with four response options each, were interspersed with the text and graphics screens.

Treatments

Two instructional treatments were utilized--learner control and program control of content review in CAI on solar energy. The instruction was the same for both the treatment groups. Both groups proceeded through the unit at their own pace, answered practice questions, and received right/wrong feedback. Following correct answers, all subjects received reinforcing informational feedback, such as "That's right. Today, most solar systems are used to heat water and inside air", or "That's right. A big problem with solar cells is that they cost a lot of money."

Following wrong answers, subjects in the learner control treatment were told their answer was incorrect and were asked, "Do you want to review before trying to answer the question again?" At a "Yes" response, the subject was branched back to the program segment covering the pertinent content. At the end of that review segment, the subject was presented with the practice question once again. A "No" response resulted in a second presentation of the practice question.

Following an incorrect response to a practice question under program control, subjects were first told their answer was not correct. Next they were told, "Let's review before you try to answer the question again." Then the subjects were routed back for review of relevant material. Following the review, a second chance was given to answer the practice question. Both learner control and program control groups received three tries at each question, with attendant options for review after the first two incorrect answers. On

the third incorrect answer, all subjects were given the correct answer, and then continued on with the instruction.

Instruments

The instruction was followed by a 25-item posttest. Fifteen of the posttest questions (referred to as principal items) paralleled content covered by the practice questions. An additional 10 items (incidental items) were included in the posttest to measure incidental learning. All of the content for the incidental items was included within the available content review screens, as well as in the initial presentation.

Following the posttest, students completed a seven-item questionnaire measuring attitudes toward the unit itself and toward solar energy. Students were also asked how often they used a computer.

Procedures

Subjects were first blocked on the basis of gender. Next a median split was conducted on standardized reading ability test scores from the previous year. The median grade equivalent score was 8.0 for females and 8.4 for males. Subjects from the resulting four cells were then randomly assigned to either the learner control or program control treatments.

The study was conducted in the school's computer laboratory over four consecutive days. Apple II+ and IIe computers were used. Administration of the instructional treatment and dependent measures was completed within a single class period for each subject.

When students arrived at the laboratory, they went directly to the computer which displayed their name on the screen and contained their pre-assigned instructional program. The students were told that they would be helping to evaluate some instructional materials. The experimenters explained that the instruction covered an introduction to solar energy and that it would be followed by a test to see how much they learned and a questionnaire to find

out how they felt about the instruction. The students were told that while their test scores would not impact on their class grade, their instructors would be looking over their tests so they should try hard to do well.

The number of repeated practice questions, the number of reviews selected/assigned for each question, and the time to completion were recorded for each student. The instruction, the posttest, and the questionnaire were completed in a mean time of 31 minutes.

Data Sources and Analysis

A 2 x 2 x 2 (Control x Gender x Reading Ability) design was used. Posttest performance was analyzed using analysis of variance (ANOVA). Attitudinal and computer use data from the questionnaire were analyzed by a multivariate analysis of variance (MANOVA). Enroute data were analyzed with Chi Square procedures.

## Results

Principal Items

The data for posttest performance on principal items--those items parallel to the practice items--are shown in Table 1. Significant main effects were obtained for the experimental treatment, gender, and for reading ability. Mean scores were 10.04 correct out of 15 (67%) for learner control and 9.02 correct (60%) for program control, $F(1,90) = 4.653$, $p < .03$. Boys achieved a mean score of 10.15 correct (68%), outperforming girls at 8.78 correct (59%), $F(1,90) = 7.233$, $p < .01$. As might be expected, subjects of higher verbal ability (11.14 correct, 74%) did better than those of lower ability (7.88 correct, 53%), $F(1,90) = 46.93$, $p < .0001$.

The ANOVA also yielded a significant three-way interaction for treatment by gender by reading ability, $F(1,90) = 4.831$, $p < .03$. The interaction is illustrated in Figure 1.

Differences between the cell means were analyzed using the Tukey studentized range test. The interaction reflects a pattern in which high ability females and low ability males performed significantly better under learner control as opposed to program control. High ability females achieved a mean score of 12.00 correct (80%) under learner control and 8.91 correct (59%) under program control, ($p < .01$). Low ability males in the learner control treatment scored a mean of 9.00 correct (60%) while low ability males in the program control treatment scored 8.00 correct (53%), ($p < .01$).

For high ability males there were no differences between learner and program control treatments. Both groups did significantly better than all other groups except for high ability females under learner control. No performance differences were observed between treatment groups for low ability females, who performed significantly worse than all other groups except for the low ability males under program control.

Examination of the interaction reveals that the learner versus program control differences among high ability females and low ability males account for the significant overall difference favoring learner control. The mean of the combined scores for high ability females and low ability males are 10.50 for learner control and 8.46 for program control, a difference of more than two points between the two treatments. The mean of the combined scores for low ability females and high ability males are 9.46 for learner control and 9.48 for program control, a negligible difference.

Incidental Items

Performance on the content for which there was no direct practice was reflected by scores on the incidental items. These scores were low for all groups, ranging from a high of 1.8 out of 10 correct (18%) to a low of .8 correct (8%), with an overall mean performance of 1.3 (13%). There were no significant between group differences on the incidental items.

Attitudes and Computer Use

The overall student attitude towards instruction was generally positive as indicated by a mean of 2.1 ( 1 = high, 4 = low) on the student questionnaire. The MANOVA performed on the attitude and computer use items yielded no significant differences between the learner and program control groups.

Significant MANOVA effects were found for gender, $F(7,84) = 3.53$, $p < .002$, and for reading ability $F(7,84) = 3.41$, $p < .003$. Univariate analyses of questionnaire data revealed that boys liked the instruction better than girls, $F(1,90) = 5.47$, $p < .02$, and reported more frequent computer use, $F(1,90) = 15.1$, $p < .0005$. Students of higher reading ability also reported more frequent computer use than students of lower ability $F(1,90) = 13.70$, $p < .0005$. Higher ability students reported that the unit was easier to understand, $F(1,90) = 5.79$, $p < .02$, and felt more confidence in the amount that they learned, $F(1,90) = 4.28$, $p < .04$.

Enroute Variables

Subjects under program control, of course, were routed back to the relevant instructional content each time they missed a practice item. Subjects under learner control, on the other hand, had the choice of reviewing or not reviewing the relevant content for each practice item they missed. Data on enroute performance during instruction revealed that the learner control subjects chose to review after 28% of the practice items they missed and not to review it after the remaining 72% of missed items. (Subjects under learner control who answered all practice questions correctly had no opportunities for review and hence were excluded from consideration).

To examine differences in proportion of reviews selected between subjects who had the option to choose, Chi Square analyses were conducted using subjects under learner control. Male subjects selected a mean of 43% of the possible reviews, a significantly

higher proportion than the 29% chosen by females, $\chi^2$ (1, N = 42) = 4.0, p<.05. High ability students under learner control selected a mean of 49% of the possible reviews, a significantly higher proportion than the 24% selected by students of lower ability, $\chi^2$ (1, N = 42) = 13.0, p<.001.

Times to completion were similar for all groups. Mean completion times were 31 minutes for both learner control and program control subjects, 30 minutes for high ability students and 32 minutes for low ability students, and 31 minutes for males and 32 for females.

## Discussion

The better overall performance of subjects under learner control conflicts with the results of some past learner control research (e.g., Fisher et al., 1975; Fry, 1972; Goetzfried & Hannafin, 1985). The differences in results may be due to variations in the instructional design of the CAI across studies. This study was designed so that both treatments were based on effective instructional procedures. All students were required to interact with the practice questions until they answered the questions correctly or until the third incorrect response, when they were given the correct answer. In this way, learner control subjects received repeated practice on items they initially answered incorrectly, even if they chose not to review the instructional content related to those items.

The importance of providing practice and review for important elements of instructional content is underscored by the dramatic differences in posttest scores between principal items and incidental items. The instructional content on which the principal items were based was content that students in both treatments practiced with and reviewed, if necessary. Cell means on incidental items ranged from a low of 8% to a high of 18% while scores for principal items ranged from a low of 47% to a high of 80%. These results

are consistent with those obtained by Hannafin and associates (Hannafin, Phillips, & Tripp, 1986; Hannafin & Colamaio, 1986).

The form of learner control offered successfully here and by Campanizzi (1978) are very similar. Both can be thought of as offering a kind of advisement to the learner, much as recommended by Tennyson and his colleagues (Tennyson, 1980, 1981; Tennyson & Buttrey, 1980). In Campanizzi's study and the present one, the students were told when a response was incorrect and were offered the chance to review. Even when students do not choose to review the content, the informational feedback may be sufficient to mediate a correct response. Mager (1964) points out that program controlled instruction may get in the way of the learner, by "requiring the student to study *all* of the pieces of the subject matter rather than only those he didn't already know" (p.8).

The significant overall difference in favor of learner control is primarily attributable to the stronger performance of high ability females and low ability males under the learner control condition. The effect was most pronounced among high ability girls. Under learner control, high ability girls had the highest score of any of the eight groups, scoring slightly higher than high ability boys under either treatment and averaging three more items correct than high ability girls under program control. High ability girls under program control, in fact, scored lower than low ability boys under learner control, a surprising result. Despite their higher ability, their mean score fell within the range of the four low ability cells, rather than near the scores of the other three high ability groups.

An explanation for the marked difference in performance of high ability girls under learner control and those under program control does not come easily. The difference may possibly be related to less positive general attitudes of females toward computers and towards science related subjects. Under program control, subjects had no other option than to experience the complete computer-based version of this science related program.

Learner control subjects, on the other hand, could choose to bypass reviews of the content for each item they missed. This measure of control over the completed sequence and science-related content may have mitigated the less positive attitudes for high-ability girls in the learner control group. Such an effect could conceivably result in higher performance for high ability girls under learner control than for their couterparts under program control.

The overall results support Snow's (1980) observation that individual characteristics not under the individual's control will have a significant effect on learning from instruction. Two such individual characteristics, reading level and gender, accounted for the most variance in posttest performance in the present study. The experimental treatment accounted for a significant amount, but less than the individual characteristics not directly under the control of an instructor or experimenter.

The results obtained here are partially consistent with the results found by Fry (1972) who found that high ability students who were also classified as "high inquiry" performed best when allowed to control the sequence of topics covered within instruction; low ability, low inquiry subjects in all treatments did poorly on the posttest. In this study, high ability girls performed best under learner control of content review, while there were no differences between treatments in the posttest performance for low ability girls, all of whom performed poorly.

Low ability students under learner control selected a significantly smaller proportion of possible content reviews than high ability students and performed worse on the posttest than did higher ability students. Lower ability students had many more opportunities for review than higher ability students because they answered more of the practice questions incorrectly. Their selection of a smaller proportion of reviews may reflect an overall pattern of lower motivation among students who have a low self-concept of ability (cf. Deci, 1975; Weiner, 1979).

Both the learning and the attitude data collected here support previous findings related to gender. Boys did better overall on the principal items than girls, selected a higher proportion of content reviews, liked the instruction more, and reported more frequent computer use. The domains of math and science, as well as computers, carry with them connotations of sex-related performance and attitudinal differences (Maccoby & Jacklin, 1974; Miura, 1986; Lepper & Chabay, 1985).

Learner control subjects took as much time to complete the unit as did program control subjects, even though they selected significantly fewer content reviews. Additionally, learner control subjects performed significantly better on the posttest than program control subjects. These results suggest that, when given some control over their progress through a program, students may adjust their study behaviors in a manner that enables them to achieve better posttest performance than when their sequence is completely fixed.

Differential effects of learner control and program control across studies may well be a function of learner and program control conditions. The favorable results for learner control found here may be due to the fact that all subjects were required to respond initially to all practice questions. Therefore the danger of learner control subjects missing needed practice was minimized. The results suggest that care should be taken in future research to base treatments for all levels of learner and program control on instructionally effective techniques.

Results of this research indicate several possible research directions regarding learner control and interactive instruction. First, different types of instructional support offered within CAI should be examined for effectiveness--for example, content reviews such as those used here might be compared with a highly individualized form of feedback designed to explain why chosen responses to practice questions are incorrect. Second, the

effect of learner control over these different forms of instructional support should be studied, both in terms of performance and attitudes. Particularly important here will be the determination of possible differential effects by gender and ability and the design of treatments to maximize postive effects across all subjects.

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Table 1

Mean Performance Scores on Principal Posttest Items by Treatment, Gender, & Reading Ability

| | Treatment | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Learner | | | Program | | | Total | | |
| Group | n | M | SD | n | M | SD | n | M | SD |
| Females | | | | | | | | | |
| High | 11 | 12.00 (80%)[a] | 1.34 | 11 | 8.91 (59%) | 2.59 | 22 | 10.45 (70%) | 2.56 |
| Low | 11 | 7.00 (47%) | 3.10 | 13 | 7.46 (50%) | 1.94 | 24 | 7.25 (48%) | 2.49 |
| Males | | | | | | | | | |
| High | 13 | 11.92 (79%) | 1.55 | 14 | 11.50 (77%) | 1.87 | 27 | 11.70 (78%) | 1.71 |
| Low | 12 | 9.00 (60%) | 1.81 | 13 | 8.00 (53%) | 3.49 | 25 | 8.48 (57%) | 2.80 |
| Total | 47 | 10.04 (67%) | 2.88 | 51 | 9.02 (60%) | 2.95 | 98 | 9.51 (63%) | 2.95 |

Main Effects:

| Treatment | Gender | Reading Ability |
|---|---|---|
| Learner Control: | Male: | High: |
| M = 10.04 (67%) | M = 10.15 (68%) | M = 11.14 (74%) |
| SD = 2.88 | SD = 2.80 | SD = 2.20 |
| Program Control: | Female: | Low: |
| M = 9.02 (60%) | M = 8.78 (59%) | M = 7.88 (53%) |
| SD = 2.95 | SD = 2.97 | SD = 2.70 |

[a]Mean scores are reported as total number correct (out of 15 possible). Scores expressed as a percentage are reported parenthetically.

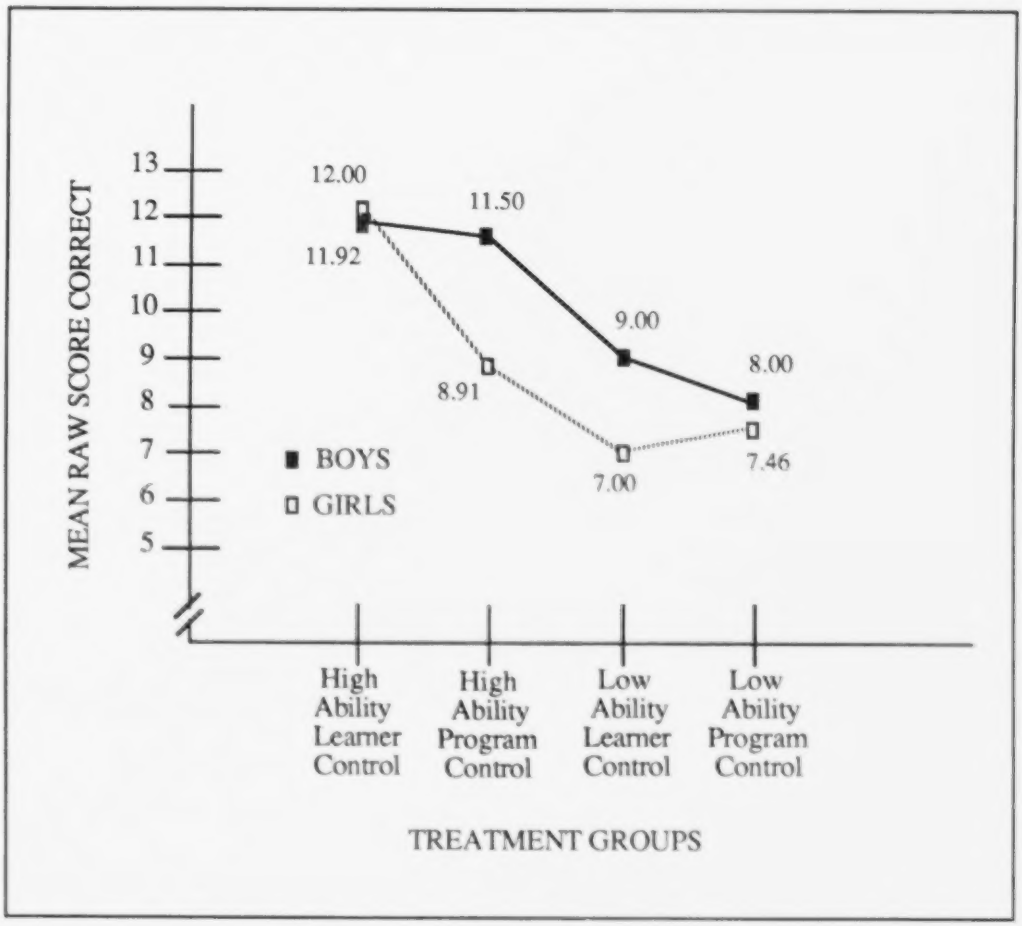


Figure 1. Reading ability by treatment by gender interaction in posttest scores on principal items.